CLAIMS

What is claimed is:

1. A method for fabrication of an ion exchange waveguide, the method comprising:

ion exchanging with a source of ions a lithium niobate ($LiNbO_3$) substrate; and

annealing to further diffuse the ion exchange in the lithium niobate substrate by heating in a sealed gas atmosphere to an anneal temperature within a range of about 100 degrees Celsius to about 1000 degrees Celsius, pressurizing the gas atmosphere to exceed ambient atmospheric pressure, maintaining temperature and pressure for an anneal period, and cooling to room temperature after the anneal period.

2. The method of claim 1 wherein ion exchanging with a source of ions further comprises ion exchanging with a source of deuterated ions.

3. The method of claim 2 wherein the source of deuterated ions is deuterated sulfuric acid.

4. The method of claim 2 wherein the source of deuterated ions is deuterated benzoic acid.

5. The method of claim 1 wherein said ion exchanging further comprises:

immersing the lithium niobate substrate in an ion exchange bath having a source of ions at an ion exchange temperature of about 160 degrees Celsius to about 240 degrees Celsius; and

holding the lithium niobate substrate in said ion exchange bath for a period of about 5 minutes to about 270 minutes to effect about 35 percent to about 50 percent alkaline earth metal atom exchange.

6. The method of claim 1 wherein said annealing further comprises heating occurring at a rate within the range of about 0.5 degrees Celsius per minute to about 20 degrees per minute.

7. A method in accordance with claim 1 wherein the anneal temperature is limited to a maximum value within a temperature range of about 100 degrees Celsius to about 600 degrees Celsius.

8. A method in accordance with claim 1 wherein the anneal temperature is limited to a maximum value of about 300 degrees Celsius.

9. The method of claim 1 wherein said pressurizing includes pressurizing the oxygen gas atmosphere to a pressure within a range of about 1 psi above ambient atmospheric pressure to about 25 psi above ambient atmospheric pressure.

maintaining temperature and pressure for a period of at least about 4 hours; and

cooling the structure to ambient temperature.

16. The method of claim 15 wherein said maximum anneal temperature is in a range of about 100°C to about 1000°C.

17. The method of claim 15 wherein said maximum anneal temperature is in a range of about 300 degrees Celsius to about 600 degrees Celsius.

18. The method of claim 15 wherein said maximum anneal temperature is about 300 degrees Celsius.

19. The method of claim 15 wherein said pressurizing includes pressurizing the oxygen gas atmosphere to a pressure within a range of about 1 psi above ambient atmospheric pressure to about 25 psi above ambient atmospheric pressure.

20. The method of claim 15 wherein said pressurizing includes pressurizing the oxygen gas atmosphere to a pressure of about 6 psi above ambient atmospheric pressure.

21. The method of claim 15 wherein said cooling includes cooling the substrate from the maximum anneal temperature at a rate within a range of rates of about 0.5 degrees Celsius per minute to about 40 degrees Celsius per minute.

10. The method of claim 1 wherein said pressurizing includes pressurizing the oxygen gas atmosphere to a pressure of about 6 psi above ambient atmospheric pressure.

11. The method of claim 1 wherein said cooling includes cooling the substrate at a rate within a range of about 0.5 degrees Celsius per minute to about 40 degrees Celsius per minute.

12. The method of claim 1 wherein said cooling includes cooling the substrate at a rate of about 20 degrees Celsius per minute.

13. The method of claim 1 wherein said annealing further comprises annealing in an environment comprising lithium niobate powder.

14. A method for annealing a lithium niobate substrate, the method comprising:

heating said lithium niobate substrate in an environment having lithium niobate powder disposed therein.

15. A method for annealing lithium niobate ($LiNbO_3$) structures, the method comprising:

heating a lithium niobate structure in an oxygen gas (O_2) and lithium niobate powder environment to a maximum anneal temperature;

pressurizing the sealed oxygen gas atmosphere to exceed ambient atmospheric pressure;

22. The method of claim 15 wherein said cooling includes cooling the substrate from the maximum anneal temperature at a rate of about 20 degrees Celsius per minute.

23. A method for fabrication of an ion exchange waveguide, the method comprising:

ion exchanging with a source of ions a lithium tantalate ($LiTaO_3$) substrate; and

annealing to further diffuse the ion exchange in the lithium tantalate substrate by heating in a sealed gas atmosphere to an anneal temperature within a range of about 100 degrees Celsius to about 1000 degrees Celsius, pressurizing the gas atmosphere to exceed ambient atmospheric pressure, maintaining temperature and pressure for an anneal period, and cooling to room temperature after the anneal period.

24. The method of claim 23 wherein ion exchanging with a source of ions further comprises ion exchanging with a source of deuterated ions.

25. The method of claim 24 wherein the source of deuterated ions is deuterated sulfuric acid.

26. The method of claim 24 wherein the source of deuterated ions is deuterated benzoic acid.

27. The method of claim 23 wherein said ion exchanging further comprises:

immersing the lithium tantalate substrate in an ion exchange bath having a source of ions at an ion exchange temperature of about 160 degrees Celsius to about 240 degrees Celsius; and

holding the lithium tantalate substrate in said ion exchange bath for a period of about 5 minutes to about 270 minutes to effect about 35 percent to about 50 percent alkaline earth metal atom exchange.

28. The method of claim 23 wherein said annealing further comprises heating occurring at a rate within the range of about 0.5 degrees Celsius per minute to about 20.0 degrees per minute.

29. A method in accordance with claim 23 wherein the anneal temperature is limited to a maximum value within a temperature range of about 100 degrees Celsius to about 600 degrees Celsius.

30. A method in accordance with claim 23 wherein the anneal temperature is limited to a maximum value of about 300 degrees Celsius.

31. The method of claim 22 wherein said annealing further comprises pressurizing to within a pressure range of about 1 psi above ambient atmospheric pressure to about 25 psi above ambient atmospheric pressure.

32. The method of claim 23 wherein said pressurizing includes pressurizing the oxygen gas atmosphere to a pressure of about 6 psi above ambient atmospheric pressure.

33. The method of claim 23 wherein said cooling includes cooling the substrate at a rate within a range of about 0.5 degrees Celsius per minute to about 40 degrees Celsius per minute.

34. The method of claim 23 wherein said cooling includes cooling the substrate at a rate of about 20 degrees Celsius per minute.

35. The method of claim 23 wherein said annealing further comprises annealing in an environment comprising lithium tantalate powder.

36. A method for annealing a lithium tantalate substrate, the method comprising:

heating said lithium tantalate substrate in an environment having lithium tantalate powder disposed therein.

37. A method for annealing lithium tantalate ($LiTaO_3$) structures, the method comprising:

heating a lithium tantalate structure in gas and lithium tantalate powder environment to a maximum anneal temperature;

pressurizing the sealed gas atmosphere to exceed ambient atmospheric pressure;

maintaining temperature and pressure for a period of at least about 4 hours; and

cooling the structure to ambient temperature.

38. The method of claim 37 wherein said maximum anneal temperature is in a range of about 100°C to about 1000°C.

39. The method of claim 37 wherein said maximum anneal temperature is in a range of about 100 degrees Celsius to about 600 degrees Celsius.

40. The method of claim 37 wherein said maximum anneal temperature is about 300 degrees Celsius.

41. The method of claim 37 wherein said pressurizing is to within a pressure range of about 1 psi above ambient atmospheric pressure to about 25 psi above ambient atmospheric pressure.

42. The method of claim 37 wherein said pressurizing is to a pressure of about 6 psi above ambient atmospheric pressure.

43. The method of claim 37 wherein said cooling occurring within a range of rates of about 0.5 degrees Celsius per minute to about 40 degrees Celsius per minute.

44. The method of claim 37 wherein said annealing further comprises cooling at a rate of about 20 degree Celsius per minute.

45. A method for fabrication of an ion exchange waveguide, the method comprising:

ion exchanging a crystalline substrate with a source of ions, the substrate being a composition having the formula RMO_3 where R is an alkaline earth metal, M is a Group IVB or Group VB metal and O is oxygen; and

annealing to further diffuse the ions in the crystalline substrate by heating the substrate in a sealed gas atmosphere to a maximum anneal temperature, pressurizing the sealed gas atmosphere to exceed ambient atmospheric pressure, maintaining temperature and pressure for an anneal period, and cooling the substrate to ambient temperature.

46. A method in accordance with claim 42 wherein the maximum anneal temperature is in a range of about 100°C to about 1000°.

47. The method of claim 45 wherein said ion exchanging is accomplished with a source of deuterated ions.

48. The method of claim 47 wherein the source of deuterated ions is deuterated sulfuric acid.

49. The method of claim 47 wherein the source of deuterated ions is deuterated benzoic acid.

50. The method of claim 45 wherein said ion exchanging further comprises:

immersing the crystalline substrate in an ion exchange bath having a source of ions at an ion exchange temperature in a range of about 160 degrees Celsius to about 240 degrees Celsius; and

holding the crystalline substrate in said ion exchange bath for a period in a range of about 5 minutes to about 270 minutes to effect about 35 percent to about 50 percent alkaline earth metal atom exchange.

51. The method of claim 45 wherein said heating further comprises heating the substrate to the maximum anneal temperature at a rate within a range of about 0.5 degrees Celsius per minute to about 20.0 degrees per minute.

52. The method of claim 45 wherein said maximum anneal temperature is within a temperature range of about 300 degrees Celsius to about 600 degrees Celsius.

53. The method of claim 45 wherein said maximum anneal temperature is about 300 degrees Celsius.

54. The method of claim 45 wherein said pressurizing includes pressurizing the sealed atmosphere to a pressure within a range of about 1 psi above ambient atmospheric pressure to about 25 psi above ambient atmospheric pressure.

55. The method of claim 45 wherein said pressurizing includes pressurizing the sealed atmosphere to a pressure of about 6 psi above ambient atmospheric pressure.

56. The method of claim 45 wherein said cooling includes cooling the substrate from the maximum anneal temperature at a rate in a range of about 0.5 degrees Celsius per minute to about 40 degrees Celsius per minute.

57. The method of claim 45 wherein said cooling includes cooling the substrate from the maximum anneal temperature at a rate of about 20 degrees Celsius per minute.

58. The method of claim 45 wherein said annealing further comprises annealing in an environment comprising a powder formed of RMO_3;

59. A method for annealing a crystalline substrate having the formula RMO_3 where R is an alkaline earth metal, M is a Group IVB or Group VB metal and O is oxygen, the method comprising:

heating said crystalline substrate in an environment having powder also formed of RMO_3.

60. An annealing container comprising:

a region containing a crystalline substrate to be annealed;

a second region containing a powder, said powder being of the same composition as the crystalline substrate; and

a porous wall separating said first region from said second region, said wall allowing for the free flow of gas between said first region and said second region.

61. A container in accordance with claim 60 wherein said first region includes a first opening, said second region includes a second opening and further comprising:

a first and second cap that respectively fit loosely over said first and second openings, wherein said caps allows for gas to flow into the container when a pressure differential exists between an interior and an exterior of the container and said caps restrict the flow out of said container of gas outgassed during an anneal process when no such pressure differential exists.

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62. An ion exchange waveguide, comprising:

a substrate formed of RMO_3 where R is an alkaline earth metal, M is a Group IV B or Group V B metal and O is oxygen;

a waveguide disposed in said substrate; and

deuterons disposed in said waveguide and exchanged for at least 1% of the R atoms in the substrate.

63. A waveguide according to claim 62 wherein said substrate comprises lithium niobate.

64. A waveguide according to claim 62 wherein said substrate comprises lithium tantalate.

65. The method of claim 1 wherein said gas is oxygen (O_2).

66. The method of claim 1 wherein said gas is one or more gasses selected from the groups consisting of Nitrogen (N_2), Argon (Ar), Helium (He) and Oxygen (O_2).

67. The method of claim 23 wherein said gas is oxygen (O_2).

68. The method of claim 23 wherein said gas is one or more gasses selected from the groups consisting of Nitrogen (N_2), Argon (Ar), Helium (He) and Oxygen (O_2).

69. The method of claim 37 wherein said gas is oxygen (O_2).

70. The method of claim 37 wherein said gas is one or more gasses selected from the groups consisting of Nitrogen (N_2), Argon (Ar), Helium (He) and Oxygen (O_2).

71. The method of claim 45 wherein said gas is oxygen (O_2).

72. The method of claim 45 wherein said gas is one or more gasses selected from the groups consisting of Nitrogen (N_2), Argon (Ar), Helium (He) and Oxygen (O_2).